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(54) **POWER TOOL AND CONTROLLER**

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(Continued)

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,536,536 B1 3/2003 Gass et al.
8,674,640 B2 * 3/2014 Suda B25B 21/00 173/176

(Continued)

FOREIGN PATENT DOCUMENTS

JP 2012-76179 A 4/2012
WO 2013/136711 A2 9/2013

OTHER PUBLICATIONS

Extended European Search Report dated Apr. 11, 2016, issued in European Patent Application No. 15196429.3.

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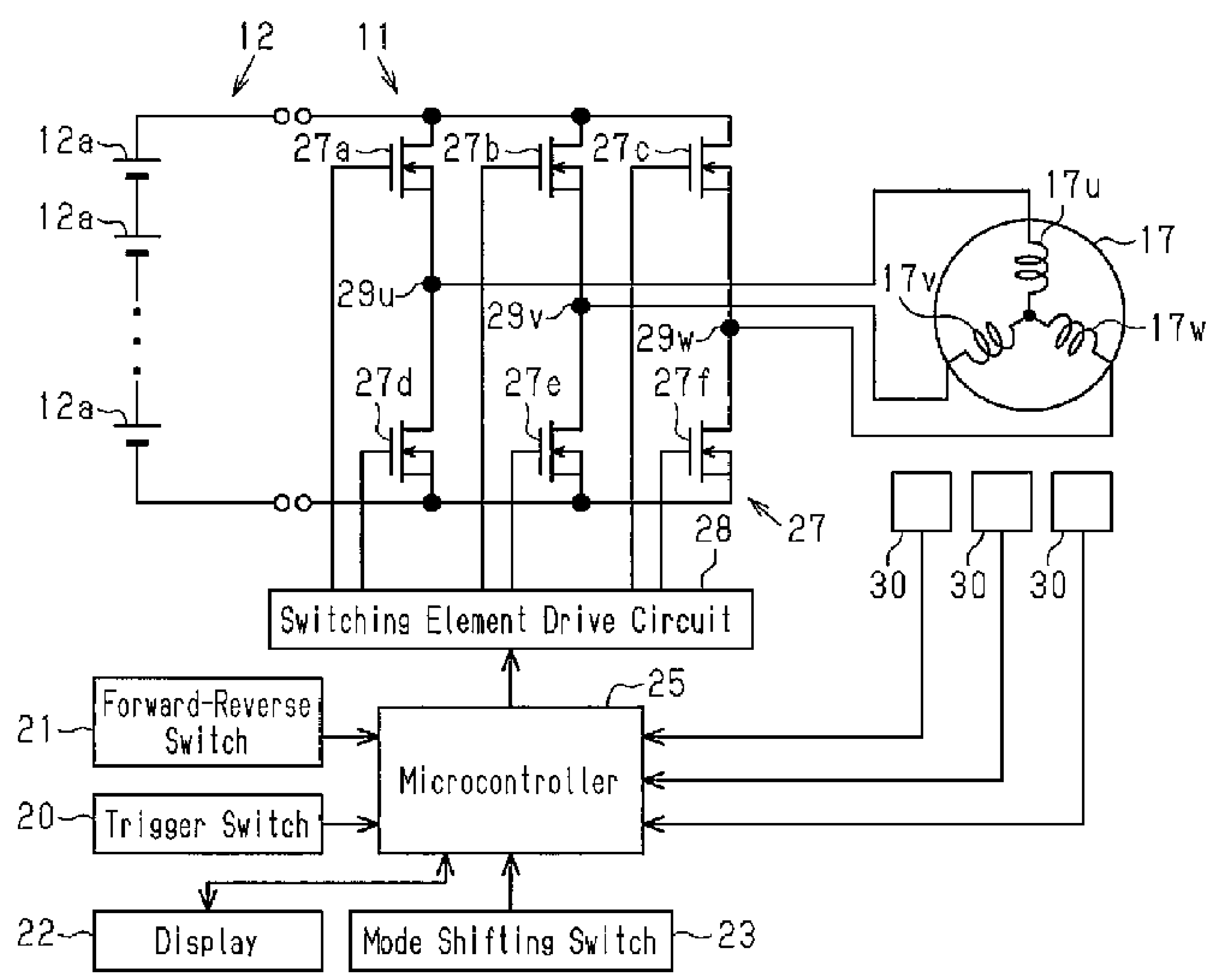
(57) **ABSTRACT**

A power tool includes a motor, a drive unit driven by the motor, and a trigger switch and a forward-reverse switch each operable by a user. The trigger switch is switchable between an activation state and a deactivation state. The forward-reverse switch switches a motor rotation between forward and reverse. The power tool also includes a control unit that drives the motor based on operation of the trigger switch and allows switching of an operation mode of the power tool between first and second modes. In the first mode, the motor rotation is switched to that selected by the forward-reverse switch. In the second mode, when the activation state is switched to the deactivation state, the motor rotation is switched so that the motor is driven in a direction opposite to the present rotation direction when the trigger switch is activated next.

7 Claims, 3 Drawing Sheets



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B25F 5/00 (2006.01)
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(58) **Field of Classification Search**
CPC .. B25B 23/14; B25F 5/00; B25F 5/021; B25F 5/001; B25F 5/02; B25D 16/006; B25D 16/003; B25D 2216/0023; B25D 2216/0038
USPC 318/17, 446, 400.12; 388/935, 937; 173/93
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

8,919,456 B2 * 12/2014 Ng B25B 23/147 173/11
8,981,680 B2 * 3/2015 Suda B25F 5/00 315/314
9,302,376 B2 * 4/2016 Agehara B25B 21/02
9,314,908 B2 * 4/2016 Tanimoto B25B 21/02
9,522,461 B2 * 12/2016 Oomori B25B 21/00
2012/0169256 A1 * 7/2012 Suda B25B 21/00 318/17
2012/0199372 A1 * 8/2012 Nishikawa B25B 23/1475 173/132
2012/0279736 A1 * 11/2012 Tanimoto B25B 21/02 173/2
2013/0008679 A1 * 1/2013 Nishikawa B25B 23/1475 173/93
2013/0014967 A1 * 1/2013 Ito B25F 5/00 173/93
2013/0087355 A1 * 4/2013 Oomori B25B 21/00 173/47
2013/0105187 A1 * 5/2013 Agehara B25B 21/02 173/20
2013/0126202 A1 * 5/2013 Oomori B25B 21/02 173/217
2013/0292147 A1 * 11/2013 Mergener B25F 5/001 173/20
2013/0327552 A1 * 12/2013 Lovelass B25F 5/00 173/1
2013/0331994 A1 * 12/2013 Ng B25B 23/147 700/275
2014/0284070 A1 * 9/2014 Ng B25F 5/00 173/2

* cited by examiner

Fig.1

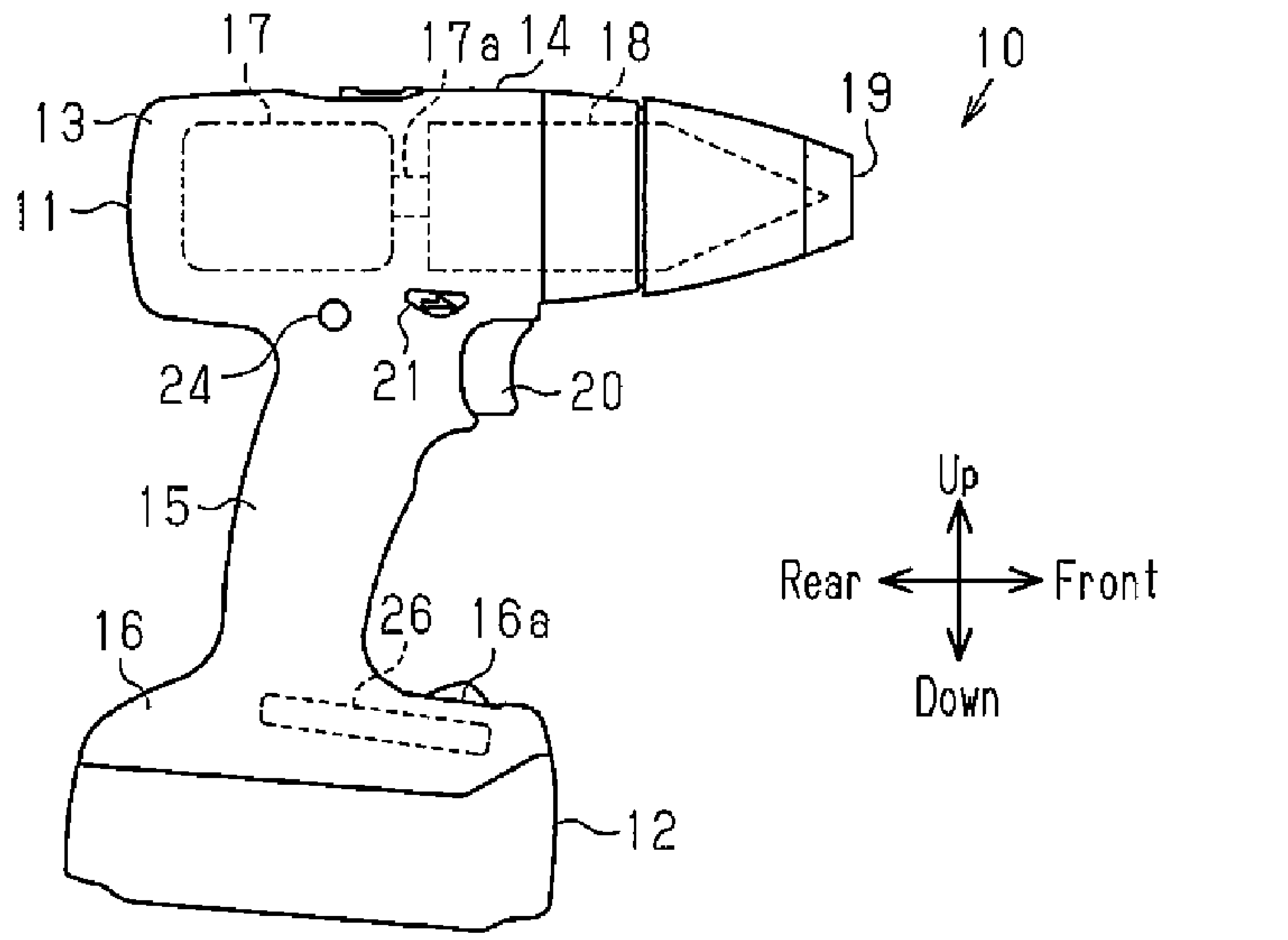

10
11
12
13
14
15
16
16a
17
17a
18
19
20
21
24
26
Up
Down
Rear
Front

Fig.2

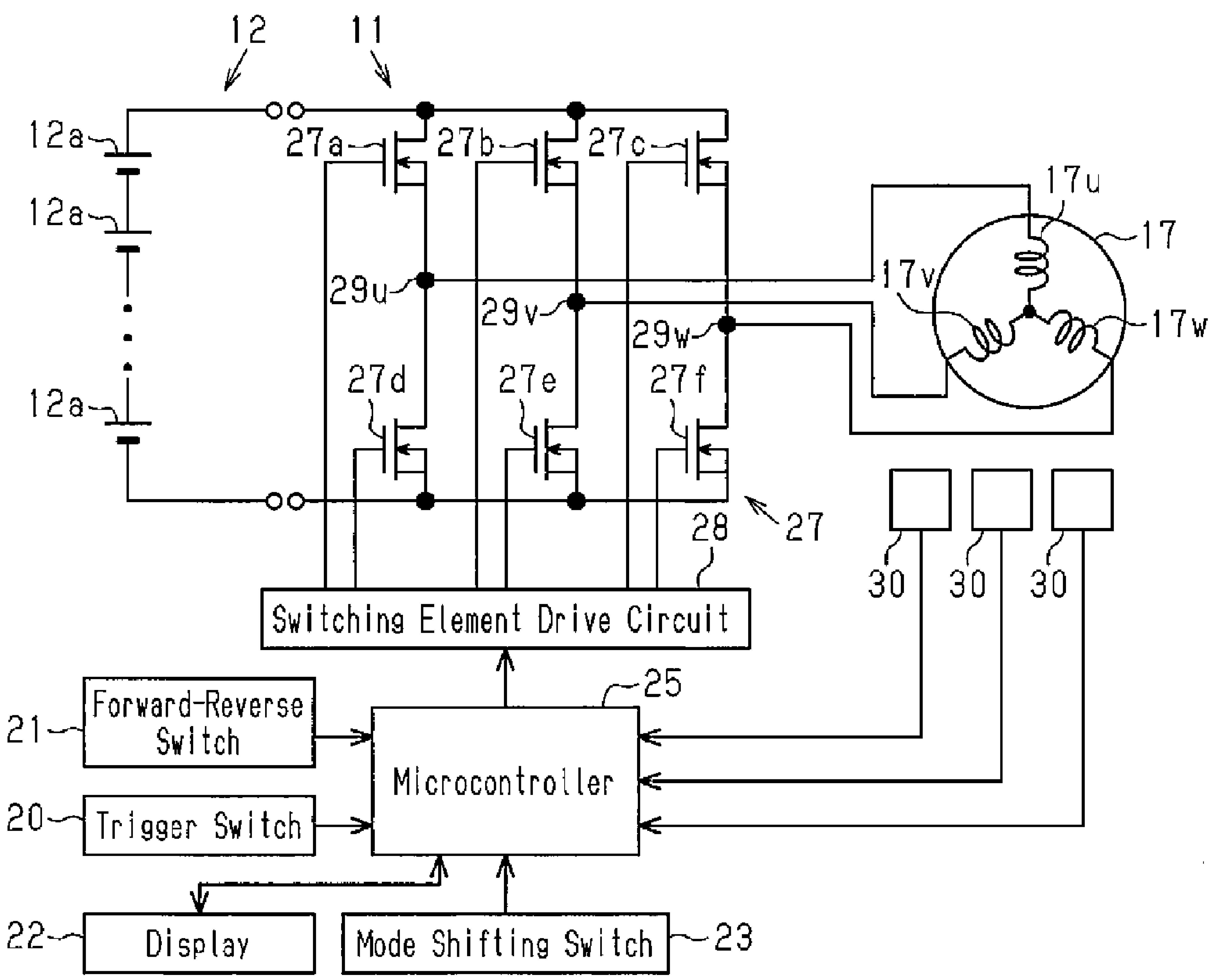

12
11
12a
27a
27b
27c
29u
29v
29w
27d
27e
27f
17u
17v
17w
17
27
28
30
Switching Element Drive Circuit
25
Forward-Reverse Switch
21
Microcontroller
20
Trigger Switch
22
Display
Mode Shifting Switch
23

Fig.3

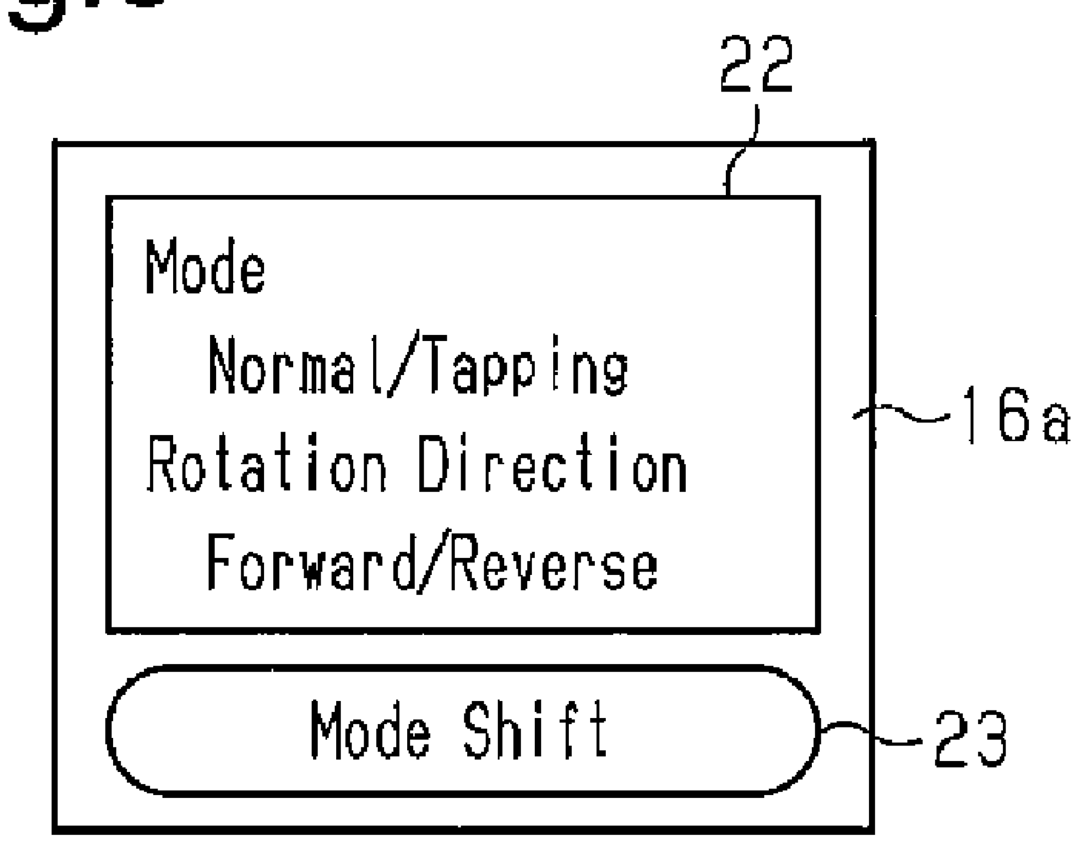

22
Mode
Normal/Tapping
Rotation Direction
Forward/Reverse
16a
Mode Shift
23

Fig.4

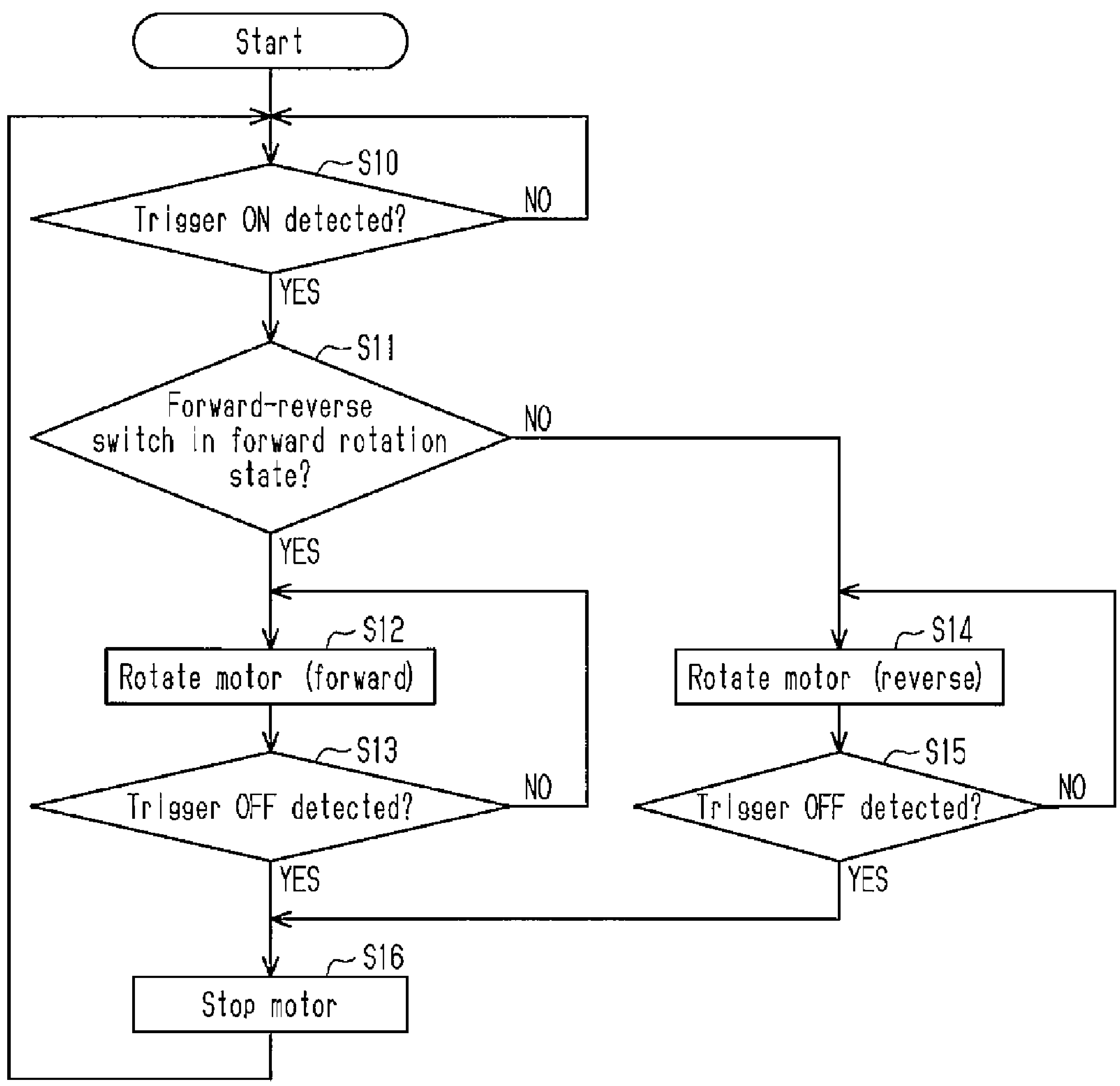
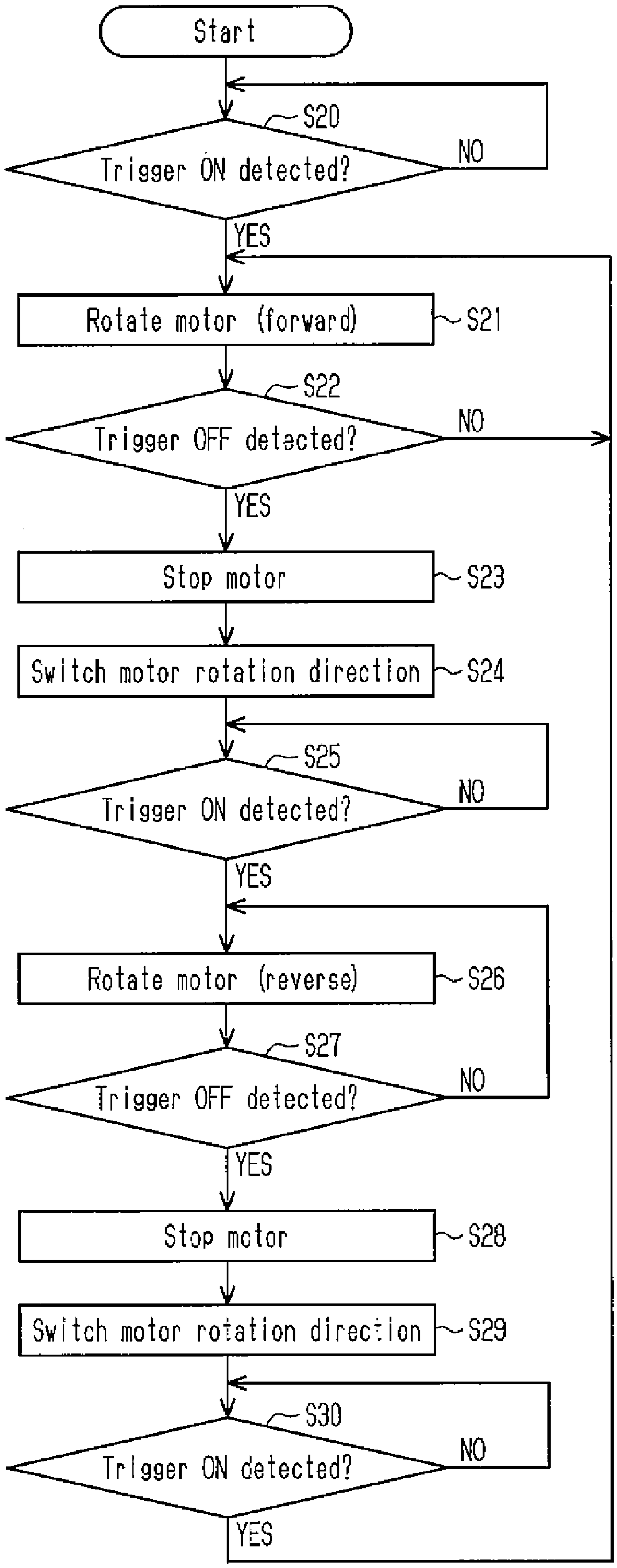

Start
S10
Trigger ON detected?
NO
YES
S11
Forward-reverse switch in forward rotation state?
NO
YES
S12
Rotate motor (forward)
S14
Rotate motor (reverse)
S13
Trigger OFF detected?
NO
S15
Trigger OFF detected?
NO
YES
YES
S16
Stop motor

Fig.5


Start
S20
Trigger ON detected?
NO
YES
Rotate motor (forward)
S21
S22
Trigger OFF detected?
NO
YES
Stop motor
S23
Switch motor rotation direction
S24
S25
Trigger ON detected?
NO
YES
Rotate motor (reverse)
S26
S27
Trigger OFF detected?
NO
YES
Stop motor
S28
Switch motor rotation direction
S29
S30
Trigger ON detected?
NO
YES

POWER TOOL AND CONTROLLER

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is based upon and claims the benefit of priority from prior Japanese Patent Application No. 2014-251774, filed on Dec. 12, 2014, the entire contents of which are incorporated herein by reference.

FIELD

This disclosure relates to a power tool and a controller thereof.

BACKGROUND

Various types of power tools such as a drill driver and an impact driver include a motor capable of generating forward rotation and reverse rotation as a drive source (e.g., refer to Japanese Laid-Open Patent Publication No. 2012-76179). A power tool includes a housing, which accommodates a motor. Rotational drive force is transmitted from the motor to an output shaft to rotate a bit, which is attached to an attachment portion coupled to the output shaft. The power tool includes a forward-reverse switch, which switches the rotation direction of the bit, that is, the rotation direction of a motor shaft. The rotation direction of the bit may be manually switched . . . .

In the power tool, various bits may be attached to the attachment portion. For example, a tap (point tap) may be used as the bit to perform threading (tapping).

SUMMARY

When a tap is used as the tip of a power tool to perform tapping and the tap is continuously rotated forward to form a thread, the removal of chips may be difficult. In this case, the chips may be removed, for example, by operating the forward-reverse switch to reverse the rotation direction of the bit. However, repetitive operation of the forward-reverse switch that switches the rotation direction of the tap to remove chips may be very burdensome to the user.

This disclosure contemplates a power tool and a controller thereof that allow a user to easily perform tapping.

The first aspect of this disclosure is a power tool. The power tool includes a motor, a drive unit driven by the motor, a trigger switch, a forward-reverse switch, and a control unit. The trigger switch is operable by a user and switchable between an activation state, in which the motor is driven, and a deactivation state, in which the motor is stopped. The forward-reverse switch is operable by the user and used to switch a motor rotation direction between a forward rotation direction and a reverse rotation direction. The control unit drives the motor based on an operation of the trigger switch. The control unit is adapted to allow an operation mode of the power tool to be switched between a first mode and a second mode. In the first mode, the control unit switches the motor rotation direction to a rotation direction that is selected by the forward-reverse switch. In the second mode, when the trigger switch is switched from the activation state to the deactivation state, the control unit switches the motor rotation direction so that the motor is driven in a rotation direction opposite to the present rotation direction when the trigger switch is activated next.

The second aspect of this disclosure is a controller that controls a power tool. The controller includes a control unit that has the same features as the first aspect described above.

The power tool and the controller of this disclosure allow a user to easily perform tapping.

Other aspects and advantages of the invention will become apparent from the following description, taken in conjunction with the accompanying drawings, illustrating by way of example the principles of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention, together with objects and advantages thereof, may best be understood by reference to the following description of the presently preferred embodiments together with the accompanying drawings in which:

FIG. **1** is a schematic diagram illustrating one embodiment of a power tool;

FIG. **2** is a schematic block diagram illustrating a drive control system of the power tool;

FIG. **3** is an illustrative diagram illustrating an example of a display and a mode shifting switch of the power tool;

FIG. **4** is a schematic flowchart illustrating an example of the operation of the power tool in a normal mode; and

FIG. **5** is a schematic flowchart illustrating an example of the operation of the power tool in a tapping mode.

DESCRIPTION OF THE EMBODIMENTS

One embodiment of a power tool **10** will now be described with reference to the drawings.

Referring to in FIG. **1**, the power tool **10** includes a power tool body **11** and a battery pack **12**, which is attached to the power tool body **11** in a removable manner. As illustrated in FIG. **2**, the battery pack **12** incorporates a plurality of battery cells **12***a*.

The power tool body **11** includes a housing **13**. The housing **13** includes a tubular main body **14**, a handle **15**, and a battery pack seat **16**. The handle **15** extends downward from a longitudinally intermediate portion of the main body **14**. The battery pack seat **16** is located on a lower end of the handle **15**. The battery pack **12** is attachable to the battery pack seat **16**.

The main body **14** accommodates a motor **17**, which includes a motor shaft **17***a*, and a drive transmission unit **18**, which functions as a drive unit and is coupled to the motor shaft **17***a*. The drive transmission unit **18** is driven by the motor **17** and transmits rotational drive force of the motor **17** to an output shaft (not illustrated) arranged in the drive transmission unit **18**. The drive transmission unit **18** includes, for example, a speed reduction mechanism, a clutch mechanism, and the like.

The output shaft of the drive transmission unit **18** is coupled to a bit seat **19**. Thus, when the motor shaft **17***a* rotates, the bit seat **19** is rotated by the output shaft of the drive transmission unit **18**. A bit such as a driver bit or a tap may be attached to the bit seat **19** in a removable manner. Thus, the bit is rotated together with the bit seat **19**. Hereafter, an axial direction of the motor shaft **17***a* (longitudinal direction of main body **14**) is referred to as the front-rear direction of the power tool **10**, and a direction in which the handle **15** extends is referred to as the vertical direction. Additionally, a width-wise direction of the power tool **10**, which is orthogonal to the front-rear direction and the vertical direction, is referred to as the lateral direction.

The handle **15** of the power tool body **11** includes an upper end, which is provided with a trigger switch **20**. The trigger switch **20** is operable by an operator (user). The trigger switch **20**, which is used to switch activation and deactivation of the power tool **10**, may be switched between an activation state, in which the motor **17** is driven, and a deactivation state, in which the motor **17** is stopped. In the activation state, the operator pulls (presses) the trigger switch **20**. In the deactivation state, the operator does not operate the trigger switch **20**.

A forward-reverse switch **21** is arranged proximate to the trigger switch **20**. The forward-reverse switch **21** functions as a forward-reverse switch, which is used to switch the rotation direction of the bit, that is, a motor rotation direction (rotation direction of motor shaft **17***a*) between a forward rotation direction and a reverse rotation direction. The forward-reverse switch **21**, which is operable by the operator (user), outputs rotation setting information indicating the motor rotation direction. The forward-reverse switch **21** may include, for example, an operation knob, which projects from a surface of the handle **15**. In this case, when the operator shifts the operation knob between a forward rotation position and a reverse rotation position, the forward-reverse switch **21** outputs the rotation setting information indicating one of the forward rotation direction and the reverse rotation direction in accordance with the position of the operation knob.

The battery pack seat **16** is box-shaped and elongated in the front-rear direction. The battery pack seat **16** includes a front side that includes an upper surface **16***a*. The upper surface **16***a* of the battery pack seat **16** is provided with a display **22** and a mode shifting switch **23**, which functions as a mode selector (refer to FIG. **2**).

As illustrated in FIG. **3**, the display **22** may show, for example, the operation mode (one of tapping mode and normal mode) and the rotation direction of the motor **17**.

The mode shifting switch **23** is used to shift the operation state of the power tool **10** between the tapping mode and the normal mode. One example of the mode shifting switch **23** is an ON/OFF switch. In this case, when the mode shifting switch **23** is switched on, the tapping mode becomes effective, and the display **22** indicates that the power tool **10** is in the tapping mode. When the mode shifting switch **23** is switched off, the normal mode is becomes effective, and the display **22** indicates that the power tool **10** is in the normal mode.

The battery pack seat **16** accommodates a control circuit **26**, which includes a microcontroller **25** (control unit). The control circuit **26** corresponds to a controller.

As illustrated in FIG. **2**, the microcontroller **25** is electrically connected to the trigger switch **20**, the forward-reverse switch **21**, the display **22**, and the mode shifting switch **23**. Additionally, the microcontroller **25** is electrically connected to a switching element drive circuit **28**, which controls the driving of a PWM inverter circuit **27**.

The switching element drive circuit **28** is connected to switching elements **27***a* to **27***f* of the PWM inverter circuit **27**. The switching elements **27***a* to **27***f* each include, for example, an FET. The switching element drive circuit **28** is connected to the gate terminals of the switching elements **27***a* to **27***f*.

The switching elements **27***a*, **27***d* form a first series circuit. In the same manner, the switching elements **27***b*, **27***e* form a second series circuit, and the switching elements **27***c*, **27***f* form a third series circuit. The first to third series circuits are connected in parallel. The upper switches of the first to third series circuits, namely, the switching elements **27***a*, **27***b*, **27***c*, are connected to the positive terminal of the battery pack **12**. The lower switches of the first to third series circuits, namely, the switching elements **27***d*, **27***e*, **27***f*, are connected to the negative terminal of the battery pack **12**. Additionally, a connection point **29***u* between the switching elements **27***a*, **27***d*, a connection point **29***v* between the switching elements **27***b*, **27***e*, and a connection point **29***w* between the switching elements **27***c*, **27***f* are respectively connected to motor coils **17***u*, **17***v*, **17***w* of the motor **17**.

Additionally, the microcontroller **25** is connected to a plurality of rotational position detection elements **30**, which detects a rotational position of a rotor (not illustrated) of the motor **17**. In the present embodiment, three rotational position detection elements **30** are arranged in a circumferential direction of the motor **17** at intervals of approximately 120 degrees. Here, FIG. **2** does not specifically illustrate the positions of the detection elements **30**. The microcontroller **25** may detect the rotational position of the rotor of the motor **17** and whether or not the rotor of the motor **17** is rotating based on detection results of the detection elements **30**.

An example of the operation of the power tool **10** of the present embodiment will now be described.

In the power tool **10**, the mode shifting switch **23** may shift the operation mode. In the present embodiment, when the mode shifting switch **23** is in an OFF state, the power tool **10** operates in the normal mode, and when the mode shifting switch **23** is in an ON state, the power tool **10** operates in the tapping mode. Here, the normal mode corresponds to a first mode, and the tapping mode corresponds to a second mode.

Normal Mode

The normal mode will now be described.

As illustrated in FIG. **4**, the microcontroller **25** determines whether or not the trigger switch **20** is in the activation state (step **S10**). When the trigger switch **20** is in the activation state (step **S10**: YES), the microcontroller **25** determines whether or not the forward-reverse switch **21** is in a forward rotation state, or the forward-reverse switch **21** is set to a forward rotation direction (step **S11**).

When the forward-reverse switch **21** is in the forward rotation state (step **S11**: YES), the microcontroller **25** energizes the motor **17** to drive the motor **17** in the forward rotation (step **S12**). At this time, the microcontroller **25** may change the rotational speed of the motor **17**, for example, in accordance with an operation amount (pulled amount) of the trigger switch **20**. For example, the microcontroller **25** may adjust the amount of electric current supplied from the inverter circuit **27** to the motor **17** by controlling the switching element drive circuit **28** so that the rotational speed of the motor **17** increases as the pulled amount of the trigger switch **20** becomes greater.

Then, the microcontroller **25** determines whether or not the trigger switch **20** is in the deactivation state (step **S13**). When the trigger switch **20** is in the activation state (step **S13**: NO), the microcontroller **25** repeats step **S12**. More specifically, when the trigger switch **20** continues to be in the activation state, the microcontroller **25** continuously drives the motor **17** and produces the forward rotation.

When the trigger switch **20** is in the deactivation state (step **S13**: YES), the microcontroller **25** stops energizing the motor **17** to stop the motor **17** (step **S16**).

On the other hand, when the forward-reverse switch **21** is in a reverse rotation state (step **S11**: NO), the microcontroller **25** energizes the motor **17** to drive the motor **17** and produce the reverse rotation (step **S14**). At this time, the microcontroller **25** may change the rotational speed of the motor **17**, for example, in accordance with the operation amount (pulled amount) of the trigger switch **20**. For example, the microcontroller **25** may adjust the amount of electric current supplied from the inverter circuit **27** to the motor **17** by controlling the switching element drive circuit **28** so that the rotational speed of the motor **17** increases as the pulled amount of the trigger switch **20** becomes greater.

Then, the microcontroller **25** determines whether or not the trigger switch **20** is in the deactivation state (step S**15**). When the trigger switch **20** is in the activation state (step S**15**: NO), the microcontroller **25** repeats step S**14**. More specifically, when the trigger switch **20** continues to be in the activation state, the microcontroller **25** continuously drives the motor **17** and produces a reverse rotation.

When the trigger switch **20** is in the deactivation state (step S**15**: YES), the microcontroller **25** stops energizing the motor **17** to stop the motor **17** (step S**16**).

As described above, when the power tool **10** is in the normal mode, the microcontroller **25** switches the motor rotation direction to the rotation direction that is selected by the operator (user) with the forward-reverse switch **21**. In the normal mode, the display **22** shows the current motor rotation direction, which is selected by the forward-reverse switch **21**.

Tapping Mode

The tapping mode will now be described. In the present embodiment, when the power tool **10** is initially started in the tapping mode, an initial rotation direction of the motor **17** is set, for example, to the forward rotation direction. However, there is no limit to this configuration.

As illustrated in FIG. **5**, the microcontroller **25** determines whether or not the trigger switch **20** is in the activation state (step S**20**). When the trigger switch **20** is in the activation state (step S**20**: YES), the microcontroller **25** energizes the motor **17** to drive the motor **17** and produce the forward rotation (step S**21**).

Then, the microcontroller **25** determines whether or not the trigger switch **20** is in the deactivation state (step S**22**). When the trigger switch **20** is in the activation state (step S**22**: NO), the microcontroller **25** repeats step S**21**. More specifically, when the trigger switch **20** continues to be in the activation state, the microcontroller **25** continuously drives the motor **17** and produces the forward rotation.

When the trigger switch **20** is in the deactivation state (step S**22**: YES), the microcontroller **25** stops energizing the motor **17** to stop the motor **17** (step S**23**).

Then, the microcontroller **25** sets the motor rotation direction to the reverse rotation direction (step S**24**). More specifically, when the trigger switch **20** is switched from the activation state to the deactivation state, the microcontroller **25** automatically switches the motor rotation direction from the forward rotation direction to the reverse rotation direction. For example, the microcontroller **25** rewrites the rotation setting information, which is stored in a memory or a register arranged in the microcontroller **25**.

Then, the microcontroller **25** determines whether or not the trigger switch **20** is in the activation state (step S**25**). When the trigger switch **20** is in the activation state (step S**25**: YES), the microcontroller **25** energizes the motor **17** so that the motor **17** is driven in the motor rotation direction that is set in step S**24**, or the reverse rotation direction (step S**26**).

Subsequently, the microcontroller **25** determines whether or not the trigger switch **20** is in the deactivation state (step S**27**). When the trigger switch **20** is in the activation state (step S**27**: NO), the microcontroller **25** repeats step S**26**. More specifically, when the trigger switch **20** continues to be in the activation state, the microcontroller **25** continuously drives the motor **17** and produces the reverse rotation.

When the trigger switch **20** is in the deactivation state (step S**27**: YES), the microcontroller **25** stops energizing the motor **17** to stop the motor **17** (step S**28**).

Then, the microcontroller **25** sets the motor rotation direction to the forward rotation direction (step S**29**). More specifically, when the trigger switch **20** is switched from the activation state to the deactivation state, the microcontroller **25** automatically switches the motor rotation direction from the reverse rotation direction to the forward rotation direction.

Then, the microcontroller **25** determines whether or not the trigger switch **20** is in the activation state (step S**30**). When the trigger switch **20** is in the activation state (step S**30**: YES), the microcontroller **25** proceeds to step S**21** and energizes the motor **17** so that the motor **17** is driven in the motor rotation direction that is set in step S**29**, or the forward rotation direction. Subsequently, the microcontroller **25** repeats steps S**22** to S**30**.

As described above, when the power tool **10** is in the tapping mode and the trigger switch **20** is switched from the activation state to the deactivation state, the microcontroller **25** automatically switches the motor rotation direction to one that is set for the next operation. In the tapping mode, the display **22** shows whether the next motor rotation direction is the forward rotation direction or the reverse rotation direction. For example, in step S**21**, when the motor **17** is driven to produce the forward rotation, the display **22** shows that the next motor rotation direction is the reverse rotation direction. Subsequently, when the motor **17** is driven to produce the reverse rotation, the display **22** shows that the next motor rotation direction is the forward rotation direction. This allows the operator to recognize the next motor rotation direction and further accurately perform tapping. Here, in the tapping mode, the display **22** may show the current motor rotation direction together with the next motor rotation direction.

The present embodiment has the advantages described below.

(1) The microcontroller **25** may shift the operation state of the power tool **10** between the normal mode and the tapping mode. When the power tool **10** is in the normal mode, the microcontroller **25** switches the motor rotation direction to the rotation direction that is selected by the forward-reverse switch **21**. When the power tool **10** is in the tapping mode and the trigger switch **20** is switched from the activation state to the deactivation state, the microcontroller **25** switches the motor rotation direction to the rotation direction that is set when the trigger switch **20** is activated next. In this manner, during the tapping mode, the microcontroller **25** automatically switches the driving of the motor **17** between the forward rotation and the reverse rotation in response to the switching of the trigger switch **20** from the activation state to the deactivation state instead of an output of the forward-reverse switch **21**. Thus, the operator (user) does not have to operate the forward-reverse switch **21** during tapping. This reduces the burden to the operator. Additionally, the position of a contact point of the forward-reverse switch **21** does not have to be shifted between the forward rotation position and the reverse rotation position. This reduces wear of the contact point of the forward-reverse switch **21**.

(2) The power tool **10** includes the mode shifting switch **23**, which shifts the operation mode between the normal

mode and the tapping mode, and the display **22**, which shows the operation mode selected by the mode shifting switch **23**. This allows a user to check whether the current operation mode is the tapping mode or the normal mode with the display **22** when shifting the operation mode.

(3) In the tapping mode, the display **22** shows whether the next motor rotation direction is the forward rotation direction or the reverse rotation direction. This allows a user to recognize the next motor rotation direction with the display **22** and further accurately perform tapping.

(4) When the trigger switch **20** is initially activated in the tapping mode, the microcontroller **25** drives the motor **17** and produces the forward rotation. That is, in the tapping mode, the initial rotation direction of the motor **17** is set to the forward rotation direction. This reduces operation errors.

(5) In the tapping mode, the microcontroller **25** switches the rotation direction of the motor **17** after the motor **17** completely stops. This limits damage on the switching elements **27***a* to **27***f*, which switch the driving of the motor **17** between the forward rotation and the reverse rotation.

It should be apparent to those skilled in the art that the present invention may be embodied in many other specific forms without departing from the scope of the invention. Particularly, it should be understood that the present invention may be embodied in the following forms.

In the above embodiment, in the tapping mode, the initial rotation direction of the motor **17** is set to the forward rotation direction. Instead, for example, in the tapping mode, the initial rotation direction of the motor **17** may be set to the reverse rotation direction. Additionally, the microcontroller **25** may store the motor rotation direction when the tapping mode is ended. When the next tapping mode is started, the microcontroller **25** may start driving the motor **17** in the stored motor rotation direction. Alternatively, the current state of the forward-reverse switch **21** may be set to the initial rotation direction of the motor **17** in the tapping mode.

In the above embodiment, subsequent to step S**30**, step S**21** to step S**30** are repeated. However, the flowchart in FIG. **5** may be modified as long as the equivalent process is performed. For example, step S**30** may be omitted. In this case, step S**20** to step S**29** may be repeated subsequent to step S**29**.

In the above embodiment, the mode shifting switch **23** is arranged on the upper surface **16***a* of the battery pack seat **16**, which is located at the front side. However, the position of the mode shifting switch **23** may be changed.

In the above embodiment, the display **22** is arranged on the upper surface **16***a* of the battery pack seat **16**, which is located at the front side. However, the position of the display **22** may be changed. Alternatively, the display **22** may be omitted. Further, the operation mode and the motor rotation direction may be notified to a user using a means other than a display, such as a sound, a buzzer, vibration, or the like.

Although not particularly described in the above embodiment, the power tool **10** may include, for example, a rotational speed setting unit **24** that is operable by a use and capable of setting the rotational speed of the motor **17** in the tapping mode. In this case, the microcontroller **25** may control the motor **17** so that the motor **17** is driven at the rotational speed that is set by the rotational speed setting unit **24**. In such a configuration, the maximum rotational speed of the tapping mode may be set to a desired rotational speed. This improves the efficiency of the operation performed by a user. Additionally, the maximum rotational speed may be limited. This reduces damage of the bit (tap).

The above embodiment and modified examples may be combined.

This disclosure encompasses various embodiments described below.

1. A power tool including:

a motor;

a drive unit driven by the motor;

a trigger switch operable by a user and switchable between an activation state, in which the motor is driven, and a deactivation state, in which the motor is stopped;

a forward-reverse switch operable by the user and used to switch a motor rotation direction between a forward rotation direction and a reverse rotation direction; and

a control unit that drives the motor based on an operation of the trigger switch, wherein

the control unit is adapted to allow an operation mode of the power tool to be switched between a first mode and a second mode, wherein

in the first mode, the control unit switches the motor rotation direction to a rotation direction that is selected by the forward-reverse switch, and

in the second mode, when the trigger switch is switched from the activation state to the deactivation state, the control unit switches the motor rotation direction so that the motor is driven in a rotation direction opposite to the present rotation direction when the trigger switch is activated next.

2. The power tool according to clause 1, further including:

a mode selector used to switch the operation mode of the power tool between the first mode and the second mode; and

a display that shows one of the first mode and the second mode that is selected by the mode selector.

3. The power tool according to clause 2, wherein in the second mode, the display shows a next motor rotation direction when the motor is driven.

4. The power tool according to any one of clauses 1 to 3, further including:

a rotational speed setting unit operable by the user and adapted to allow a rotational speed of the motor to be set in the second mode, wherein

the control unit controls the motor so that the motor is driven at the rotational speed that is set by the rotational speed setting unit.

5. The power tool according to any one of clauses 1 to 4, wherein the control unit controls the motor so that the motor is driven in a forward rotation when the trigger switch is initially activated in the second mode.

6. The power tool according to any one of clauses 1 to 5, wherein the control unit controls the motor so that, in the second mode, the motor rotation direction is switched after the motor completely stops.

7. A controller that controls a power tool, wherein the power tool includes a motor, a drive unit driven by the motor, a trigger switch operable by a user and switchable between an activation state, in which the motor is driven, and a deactivation state, in which the motor is stopped, and a forward-reverse switch operable by the user and used to switch a motor rotation direction between a forward rotation direction and a reverse rotation direction, the controller including:

a control unit that drives the motor based on an operation of the trigger switch, wherein

the control unit is adapted to allow an operation state of the power tool to be switched between a first mode and a second mode, wherein in the first mode, the control unit switches the motor rotation direction to a rotation direction that is selected by the forward-reverse switch, and

in the second mode, when the trigger switch is switched from the activation state to the deactivation state, the control unit switches the motor rotation direction so that the motor is driven in a rotation direction opposite to the present rotation direction when the trigger switch is activated next.

The present examples and embodiments are to be considered as illustrative and not restrictive, and the invention is not to be limited to the details given herein, but may be modified within the scope and equivalence of the appended claims.

The invention claimed is:

1. A power tool comprising:

a motor;

a drive unit driven by the motor;

a trigger switch operable by a user and switchable between an activation state, in which the motor is driven, and a deactivation state, in which the motor is stopped;

a forward-reverse switch operable by the user and used to switch a motor rotation direction between a forward rotation direction and a reverse rotation direction; and

a control unit that drives the motor based on an operation of the trigger switch, wherein

the control unit is adapted to allow a mode shifting switch of the power tool to be switched between a first mode and a second mode; wherein

in the first mode, the control unit switches the motor rotation direction to a rotation direction that is selected by the forward-reverse switch,

in the second mode, when the trigger switch is switched from the activation state to the deactivation state, the control unit switches the motor rotation direction so that the motor is driven in a rotation direction opposite to the present rotation direction when the trigger switch is activated next, and

in the second mode, when the trigger switch continues to be in the activation state, the control unit continuously drives the motor in the present rotation direction.

2. The power tool according to claim **1**, wherein

the mode shifting switch is operable to select one of the first mode and the second mode, the power tool further comprising

a display that shows one of the first mode and the second mode that is selected by the mode shifting switch.

3. The power tool according to claim **2**, wherein in the second mode, the display shows a next motor rotation direction when the motor is driven.

4. The power tool according to claim **1**, further comprising:

a rotational speed setting unit operable by the user and adapted to allow a rotational speed of the motor to be set in the second mode, wherein

the control unit controls the motor so that the motor is driven at the rotational speed that is set by the rotational speed setting unit.

5. The power tool according to claim **1**, wherein the control unit controls the motor so that the motor is driven in a forward rotation when the trigger switch is initially activated in the second mode.

6. The power tool according to claim **1**, wherein the control unit controls the motor so that, in the second mode, the motor rotation direction is switched after the motor completely stops.

7. A controller that controls a power tool, wherein the power tool includes a motor, a drive unit driven by the motor, a trigger switch operable by a user and switchable between an activation state, in which the motor is driven, and a deactivation state, in which the motor is stopped, and a forward-reverse switch operable by the user and used to switch a motor rotation direction between a forward rotation direction and a reverse rotation direction, the controller comprising:

a control unit that drives the motor based on an operation of the trigger switch, wherein

the control unit is adapted to allow a mode shifting switch of the power tool to be switched between a first mode and a second mode, wherein

in the first mode, the control unit switches the motor rotation direction to a rotation direction that is selected by the forward-reverse switch,

in the second mode, when the trigger switch is switched from the activation state to the deactivation state, the control unit switches the motor rotation direction so that the motor is driven in a rotation direction opposite to the present rotation direction when the trigger switch is activated next, and

in the second mode, when the trigger switch continues to be in the activation state, the control unit continuously drives the motor in the present rotation direction.

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